

# Deformation measurements on emergency sites

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## Abstract

In the early 2000s, deformation measurement systems were successfully tested to get reliable information about the stability of damaged structures on emergency sites. Actually, about 50 teams of THW (Federal Agency for Technical Relief) all over Germany are equipped with a tachymeter-based monitoring system in order to provide valuable information for specially trained structural engineers and decision-makers. Until now, hundreds of different emergency sites like dams, buildings after explosions or collapses, instable cranes or landslides have successfully been observed by honorary teams. With the information about the actual stability of e.g. walls or rooftops, assessment of the safety of personnel, working in the danger zone, can be performed more precisely. Even changes in the situation can be monitored very fast and evacuation can be done quickly. This paper deals with different examples of emergency sites, the challenges for the teams and the experience of more than ten years of using this Emergency Site Safety System.

**Keywords:** Emergency site, THW, honorary work

## 1 Introduction

The Technische Hilfswerk (THW) is the operational civil protection organisation of the German government. With the goal of providing technical and logistical assistance in Germany and abroad, 88.000 volunteers are engaged on a regular basis. They are skilled local partners on-site who work together with the fire service, police and aid organisations, assisting in hazard prevention and mitigating the effects of accidents and disasters.

In recent years, THW volunteer operatives have been in action for a total of several million operational hours. The THW provides technical assistance during operations, which means that specialists with technical expertise can provide assistance in a range of situations, such as natural disasters, accidents or emergencies. This assistance can take different forms: it could mean the volunteers search for and rescue people, secure buildings, remove hazardous materials, or purify water for drinking. For this, THW operatives make use of their specialised equipment and expertise to provide effective technical assistance.

The THW only deploys in response to official re-

quests, which may come from the police, fire service or the governments of other countries. The THW offices with paid staff all have on-call duty services which are the point of contact for the public authorities and authorised organisations. Additionally, many municipal fire departments and emergency dispatching centres can alert the volunteer-based THW local sections.

Local sections are open to anyone becoming a new member – prior technical knowledge is not required. The THW Basic Training and other specialist courses all ensure that operatives acquire the expertise they need for their operations. (source: [https://www.thw.de/EN/THW/Organisation/Operational-organisation/operational-organisation\\_node.html](https://www.thw.de/EN/THW/Organisation/Operational-organisation/operational-organisation_node.html), last view: 29.09.2024)

## 2 Evolution of deformation measurement in THW

Often, THW is alarmed by fire fighters or police, when disasters like explosions or serious fire happen and relief units need to perform search and rescue work or need to secure the remaining structure

against further collapse in order to protect neighbouring buildings. In former days, one or more persons were assigned to keep an eye on the damaged structure to warn people working in the endangered area. This means a high risk to all affected people.

One improvement was the introduction of specially trained persons, the so called Baufachberater (structural engineer). In their civil life, they work in the field of civil construction, architecture or similar areas and got a special qualification inside THW. With this expertise, they can evaluate the structural situation of an emergency site in order to determine further steps and establish security.

In 2003, volunteers of the THW local section Berchtesgadener Land (in person: Dr. Thomas Wellenhofer) and Remscheid (in person: Christoph Rühl) had the idea to test modern geodetic monitoring systems in order to provide real measured deformation information for decision makers. After several formal steps, the first Tachymeter was delivered to the local section Berchtesgadener Land on 28th December 2006. 5 days later, the icehockey stadium in Bad Reichenhall collapsed due to heavy snowfall and the system got its first mission. During the evaluation period, further severe emergencies like the collapse of the city archive in Collogne (3th March 2009) could be successfully supported by this new technology.



Figure 1. Monitoring at the collapsed icehockey stadium Bad Reichenhall, 4th January 2006, picture: Markus Oreck THW OV Berchtesgadener Land

Until 2014, the first 20 systems were delivered to local THW sections all over Germany. Since then, the so called Einsatz-Stellen-Sicherungssystem (ESS, emergency site safety sys-

tem) have supported the structural engineers on many emergency sites. With the data of the system, situations can be assessed much better and small deformations of the site are observed in an early stadium. Therefore, a new level of safety at emergency sites can be provided. In 2023, further systems were deployed to more local THW sections, so that there are in total more than 50 systems spread over Germany, able to response to emergencies quite fast. In figure 2 the actual distribution of the teams is shown.

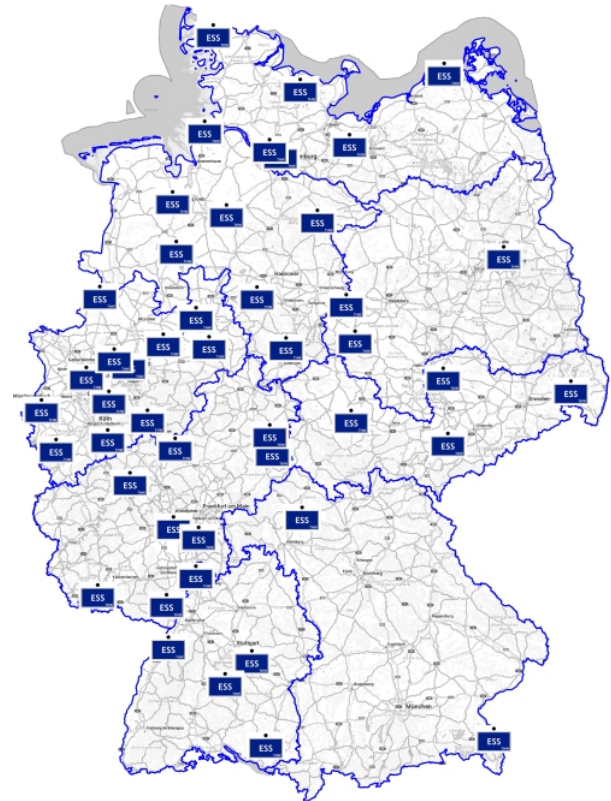


Figure 2. Distribution of the teams ESS in November 2024, map generated by: Andreas Knöpfler THW OV Landau, map data in background: adv smart mapping, blue: state associations

### 3 Equipment and Training

Due to the fact, that THW is an official institution all over Germany, there are standardisations for team, equipment and function. A team of the emergency site safety system consists of four persons: one teamleader and three trained members. A high-end total station (Leica MS50 oder MS60) is the basic sensor used by the team. Additionally, a ruggedized Laptop with Leica GeoMoS is steering the total station and collecting the data. Further

material like monitoring prisms, tools to mount the prisms and security stuff complete the equipment. To transport the equipment, vans like Sprinters of Mercedes-Benz are used. These cars also serve as a mobile office.

The main function of the ESS is the real time monitoring of emergency sites. The team further performs small surveying jobs, e.g. for the construction of temporary bridges or the determination of height differences for pumping units. Additionally, basic skills like exploration of situations or providing first aid complete the jobs of the team.

Almost 98% of the people serving in THW are volunteers. They perform training and missions beside their normal work and life: 24 hours per day, 7 days per week and 365 days a year. Most of them work in different jobs than the function they meet in THW. But all of them fulfil their honorary job with an enormous passion and dedication. After a standardized, basic training with a final exam, taking about half a year, the volunteers get special trainings for their prospective position. This specialisation takes place at the local section, in regional trainings or even at one of the three main training centres of THW in Brandenburg, Hoya or Neuhausen (see [www.thw-ausbildungszentrum.de](http://www.thw-ausbildungszentrum.de)). For the states of Hesse, Rhineland-Palatinate and Saarland, an annual training weekend for the ESS teams was initiated in 2018 by volunteers of the local section Landau/Pfalz. Since then, the eight teams of these states meet once a year to train new methods and to exchange their knowledge gained over the last year. In 2024, the main topic was height measurements and the deepening of monitoring use.



Figure 3. Annual training of ESS in Koblenz, 27th October 2024, picture: Andreas Knöpfler THW OV Landau

During the year, the local teams perform trainings on a two weekly basis. Besides monitoring and surveying, basic skills like first aid, exploration or the proper use of radio in the context of public author-

ities are trained. Altogether, team members spend between 200 and much more than 1000 hours per year of their free time as volunteers in the service of the people.

## 4 Challenges

In case of an emergency, the team is faced with different challenges. These challenges can be categorized in:

- time
- rapid decision-making
- external conditions
- collaboration

Since the team members are volunteers, they have to leave their “normal life” in case of an emergency. This means leaving their job, their family or their leisure activities right in the moment of an alert. The next step is to reach the base of the local THW section to put on the uniform, enter the vehicle and drive off to the emergency site. Despite privileges like strobe light and siren, this ride may take up to one hour or more due to the distances (compare to fig. 2). In contrast to fire fighters, THW has no commitment to reach emergency sites in a predefined time interval.

At the destination, the team leader is briefed by the local head of operations and the THW Baufachberater on the actual situation. Within short time, the monitoring scenario including the necessary measurement points at the damaged structure are defined. The next step is to setup the tachymeter as well as the mobile office. If the actual safety situation allows to fix prisms at the structure, they are fixed by screws, magnets or glue, if necessary with support of the local firefighters by turnable ladder (see fig. 4).





Figure 4. Use of a turnable ladder to mount prisms at big fire in Worms in January 2019, picture: THW OV Landau

In contrast to deformation projects in normal life where the planning of the measurement network as well as the setup of the equipment can be performed without any pressure of time, in case of emergency deformation measurement, decisions have to be made within few minutes. Due to changes in the emergency situation, permanent assessment and adaption of the setup is necessary. This may even include repositioning of the tachymeter or extension of the measurement network.

Furthermore, the teams have to deal with the external conditions at the emergency sites. Factors like weather conditions (from snowfall over rainfall up to sunshine), limited space for setup of the equipment up to the people, that are affected by the emergency have to be taken into account. Some teams even have been faced with collapsed high-rise racks in storehouses with frosty temperatures.

One essential point is the intensive collaboration between all involved organisations. Therefore, short regular meetings are held, where the teamleaders of fire service, police, ... present their actual work. On this basis, the decision-makers determine the next steps.



Figure 5. Meeting with presentation of deformation results, picture: Michael Spellmeyer THW OV Landau

It is really impressive, how all members of the so called “bluelight-family” (firefighters, police, members of THW, ...) work together in an extraordinary situation with an enormous passion and dedication.

## 5 Examples for Emergency sites

More than ten years ago, one emergency site safety system (ESS) was based at the local THW section in Landau/Pfalz. Since then, a lot of different emergency operations have been performed. In the following, some examples are shown.

One recurring scenario is the support of fire fighters during the extinction of fires or police officers during investigations after fires. In such a case, the ESS Team is monitoring the behaviour of the remaining walls while the police officers and maybe other THW personnel is working inside the building (see fig. 6).



Figure 6. Support of police investigations, 12th April 2018, picture: Andreas Knöpfler THW OV Landau

Another scenario can be the consequences of vehicles hitting buildings. In the example in fig. 7, a truck hit a carrying pillar of an industrial building. In order to stabilise the building, a temporary tower of scaffold material was built up. During the whole operation, the ESS was monitoring the situation. In this case, the movement of the construction due to upcoming rainfall could be seen in the results.



Figure 7. Monitoring of a damaged industrial building after a truck collision, picture: Andreas Knöpfler THW OV Landau

Furthermore, the ESS is called in scenarios like damaged buildings or infrastructures like bridges or towers. In August 2024, an old hotel in the village of Kröv collapsed (see fig. 8). Two persons died and seven persons were trapped under the ruins. During the rescue work, the ESS-Team of the THW section in Koblenz performed a monitoring of the remaining parts of the building in order to derive detailed information about the stability (see fig. 9). With

this information, the THW Baufachberater could do continual assessment of the situation. In the end, all seven persons could be rescued by the teams of different organisations. In scenarios like this, deformation measurements provide valuable information to guarantee safety for all people: to the rescue teams as well as to the affected people and the surroundings.



Figure 8. Collapse of a building in Kröv in August 2024, picture: Marius Grzembke THW OV Neuwied



Figure 9. ESS at collapsed building in Kröv in August 2024, picture: Marius Grzembke THW OV Neuwied

Part of the training for the ESS teams is also the ability to perform simple surveying jobs (e.g. see fig. 10). With this knowledge, basic information for shoring (measuring needed dimension of wooden beams) or the preparation of horizontal planes can

be delivered. Also, simple topographic surveys or stakeout work for the construction of temporary bridges are possible.



Figure 10. Topographic Survey, picture: Andreas Knöpfler THW OV Landau

## 6 Conclusions

Deformation measurement using tachymeters is a branch of geodesy with long history. The idea to implement this technique into the toolbox of THW in Germany offers completely new possibilities in the security of emergency sites.

From the first use at the collapse of icehockey stadium in Bad Reichenhall in December 2006 till now, the teams of the emergency site safety system (ESS) of THW in Germany could provide valuable information for decision makers in cases of emergencies all over Germany. The use of a measuring system like this is quite unique in the world of rescue workers.

## About THW

The Federal Agency for Technical Relief, or Technische Hilfswerk (THW), is a federal agency specialised in providing technical and humanitarian assistance. Its 88000 volunteer operatives help in the wake of natural disasters, accidents and other emergencies, both in Germany and abroad.

The areas of operation are diverse, ranging from search and rescue after earthquakes through flood control to technical assistance for critical infrastructure. With specialised technical units and modern equipment, THW provides assistance in many different emergency scenarios, ensuring the safety of the population. There are about 2200 paid employees providing support to the volunteers as they carry out their operations. (Federal Agency for Technical Relief, 2023)

## References

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